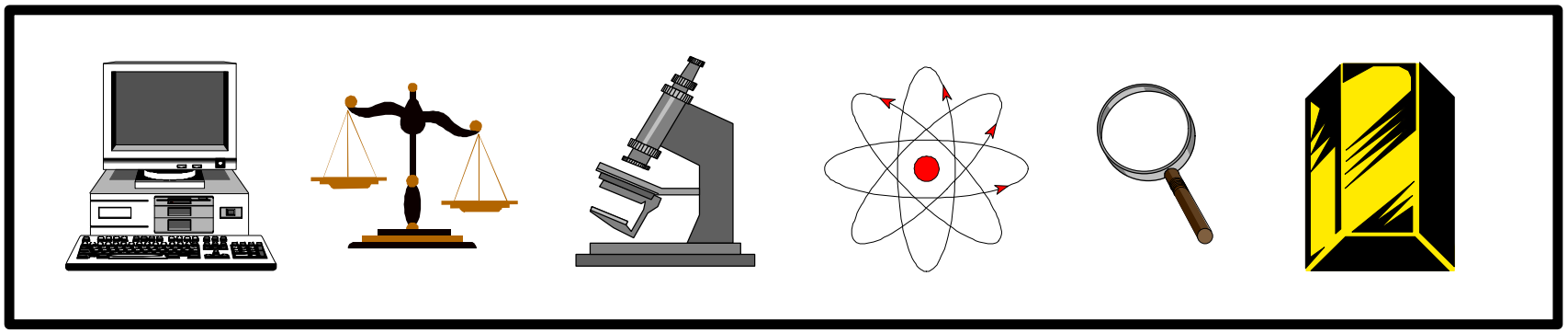
FAILURE ANALYSIS (F/A) CAPABILITIES MATRIX



Introduction

A function of the Logistics Operations Directorate (LO) is the management of tasks and activities associated with failure analysis for Shuttle hardware. LO is responsible for ensuring that failure analysis is performed by the best facility and in the most timely manner possible. In the past few years there have been numerous failure analysis capabilities developed at various facilities within the Shuttle Program. With these facilities being scattered throughout the United States, it is difficult to learn of all the failure analysis capabilities that exist within various facilities. This matrix was created in order to identify the failure analysis capabilities at the various facilities and consolidate them into one matrix. This will provide easy access to the failure analysis capabilities located at all the various facilities.

Currently, the matrix contains failure anlaysis capabilities from the facilities located at Kennedy Space Center (KSC), Cape Canaveral Air Station (CCAS), NASA Shuttle Logistics Depot (NSLD), White Sands Test Facility (WSTF), and Boeing North American Space Systems Division. The matrix is expected to grow as people begin to use it and want to add their capabilities to the matrix. The matrix was developed through a joint effort by NASA Logistics Flight Systems Engineering (LO-ENG-1) and Boeing North American M&P Engineering, Florida Operations. The matrix will be maintained and controlled by NASA Logistics Flight Systems Engineering (LO-ENG-1).

Description of the Matrix

The matrix is divided into eleven sections of different testing and/or analysis used to perform failure analysis. The first ten sections are divided into different failure anlaysis testing and section eleven consists of test facilities that have been used in the past for special failure analysis testing. Each section is divided into sub-categories providing a description of the capability, location of the capability, and equipment available at that location. The KSC/CCAS section is comprised of facilities that are identified in the bold brackets. These facilities include the Material Science Laboratory (MSL), Aerospace Fuels Laboratory (AFL), Wiltech of Florida Corp. (WT), EG&G Florida, Inc. (EG&G), and United Technologies (USBI).

Revisions, Additions, and Comments to the Matrix

The matrix will be reviewed and updated, if needed, every six months to incorporate any changes, additions, or comments. The matrix will be controlled by a revision number. This original version will be designated as revision "baseline" with superseding revisions being designated with letters of A,B,C….., etc. For the latest revision always reference the electronic copy of the Failure Analysis Matrix.

If you have any comments or see corrections that need to be made to the matrix, or to add your capabilities to the matrix, please provide information as seen on the matrix to Ken Mathews at (407)861-6458, email: kenneth.mathews-1@kmail.ksc.nasa.gov, or mail code: LO-ENG-1, Kennedy Space Center, FL 32899.

Additional Information

The matrix only provides a small amount of information about capabilities and facilities. If for any reason you need additional information on certain facilities, equipment, capabilities, can't find the capability you need, or would like to utilize any of the capabilities, please contact Ken Mathews at (407)861-6458, email: kenneth.mathews-1@kmail.ksc.nasa.gov, or mail code: LO-ENG-1, Kenedy Space Center, FL 32899.

CAPABILITIES/EQUIPMENT MATRIX

(NSLD, KSC/CCAS, Space Systems Division , WSTF)

- Optics
- Electronic Component Testing
- Mechanical/Fluids Testing
- Non-Destructive Evaluation & Test (NDE/NDT)
- Metallurgy/Fractography
- Chemical Analysis
- Non-Metallics Processing
- Physical Testing
- Optical Properties
- Space Environment Effect
- Other Capabilities

CAPABILITIES/EQUIPMENT MATRIX

Revision: Baseline

OPTICS

CAPABILITY DESCRIPTION	FLORIDA LOCATIONS		SPACE SYSTEMS DIVISION	WSTF
	NSLD	KSC/CCAS		
DOCUMENTATION OF FAILED COMPONENTS	Nikon Stereoscope • 4X to 60X with photo capability Stereoscopes Olympus Portable Microscope • 12X to 1000X Macrograph Extensive digital video documentation capabilities	Nikon Stereoscope **[MSL]** • 10X to 70X with photo capability Olympus Stereoscope **[AFL]** • with video camera Buehler Field/Portable Microscope **[MSL]** • 50X to 400X Extended Depth-of-Field Microscope **[MSL]** • macro to 85X Macrograph **[MSL]** Digitized Micrograph **[MSL]** • to 1000X Extensive digital video documentation capabilities **[MSL] [EG&G]**	Leitz Optical Stereoscope Nikon Stage Microscope • 50X to 1000X Extensive video documentation capabilities	Photomicrograph Macrograph
DETERMINE ANISOTROPIC PROPERTIES OF CRYSTALLINE MATERIALS		Nikon Polarized Light Microscope **[MSL]** Zeiss Polarized Light Microscope **[MSL]** Zeiss Polarized Light Microscope **[AFL]** • with photo capability		

CAPABILITIES/EQUIPMENT MATRIX

Revision: Baseline

ELECTRONIC COMPONENT TESTING

CAPABILITY DESCRIPTION	FLORIDA LOCATIONS		SPACE SYSTEMS DIVISION	WSTF
	NSLD	KSC/CCAS		
PARAMETRIC ELECTRICAL TEST (NON-DESTRUCTIVE)	Tektronix Programmable 370 Curve Tracer Webb Model 6200 Hermeticity Tester • gross and fine leak Hypotronics HD125/S IR & Megohmeter Hypotronics H306B-AIR & Megohmeter CMT 1210 Integrated Circuit (IC) Tester Kenrake WTR-656 Impulse Tester HP4284A LCR Bridge LCZ Meters Particle Impact Noise Detection (PIND) Sound & Light Measurement	Curve Tracers **[MSL]** Hermeticity Tester **[MSL]** • fine leak LCR Bridge **[MSL]** Hewlett Packard 16500A Logic Analysis System **[MSL]** Logic Analyzers **[MSL]** • 100KHz to 12 GHz	Curve Tracers Hermeticity Tester • fine leak AC Dielectric Tester (5KV, 50KV) Insulation Tester (5KV) LTS2020 IC Component Tester Impulse Tester LCR Bridge Particle Impact Noise Detection (PIND) Tektronics 1502C Time Delay Reflectometer	Hewlett Packard 16500A Logic Analysis System
DIAGNOSTIC ELECTRICAL TEST	 Wentworth MP-9290 Probe Station Plasma Etcher Electrical Crimp & Pull Test	Analogic Series 3000 AC/DC Power Lab **[MSL]** • with explosion chamber Probe Station **[MSL]** B&G Model 02-026 Jet Etch System **[MSL]**	 Probe Station Dage Microtester 22 Bond Pull & Die Shear Tester	
BENCH TEST EQUIPMENT	AC Distortion Analyzer AC/DC Current Meaturements Microammeter Picoammeter Resistivity Chamber Spectrum Analyzers Antenna Pattern Measure and RF Coaxial Cable Measure • 240 MHz to 15.7 GHz		AC/DC Current Measurements Microammeter Picommeter & Current Source	
DATA ACQUISITION SYSTEMS AND AUTOMATED TEST		Tektronix PEP301 386 PCs Automated Testing **[MSL]**	Computer Controlled Acquisition	Lecroy CAMAC (IEEE-583) High Speed Data Acquisition VME Bus (IEEE-1014) & Motorola Microprocessor Modular Data Acquisition and Control System
THERMAL CYCLING			RF Coax Thermal Cycling	

CAPABILITIES/EQUIPMENT MATRIX

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MECHANICAL/FLUIDS TESTING

CAPABILITY DESCRIPTION	FLORIDA LOCATIONS		SPACE SYSTEMS DIVISION	WSTF
	NSLD	KSC/CCAS		
TESTING ENVIRONMENTS	Tenney Thermal Vacuum Chamber • -70 to 177C @ 7.5x10 $^{-8}$ Torr Dispatch Oven • 850F maximum Lunaire Vacuum Bake Oven • 300F maximum @ 1x10 $^{-4}$ Torr Tenney Programmable Oven • in 100,000 clean room • -320 to 400F Programmable Furnace • to 2000F maximum Liquid Nitrogen • -320F	Conventional Ovens **[MSL]** • to 1200F **[AFL]** Elevated Temp Using Muffle Furnace • to 2000F **[AFL]** Liquid Nitrogen **[MSL] [AFL]** • -320F	Conventional Ovens • -300 to 1200F Elevated Temp Using Quartz Lamps • to 2200F Elevated Temp Using Tube Furnace • to 3000F Liquid Nitrogen • -320F Liquid Hydrogen and Helium • -423F	
HYDRAULIC TESTING	Hydraulic Testing • limited to Orbiter brakes, static testing only	Hydraulic Testing • limited capability **[AFL]** • 5000 psig Sprague Engineering test bench for static and cyclical testing **[MSL]** • 5000 psig @ 17 gpm **[WT]** SRB Hydraulic LRUs **[USBI]** Static Test Bench **[USBI] [WT]** • 15,000 psig **[WT]**	Hydraulic Testing	Hydraulic Testing • 30,000 psig
CRYOGENIC TESTING	Static Testing • 64 cu. ft. test chamber • -325 to 400F Dynamic Testing • LN_2 flow from 1,500 gallon tank	Static Testing **[WT]** • 64 cu. ft. test chamber • -325 to 400F Dynamic Testing **[WT]** • LN_2 flow test capability up to 10 gpm		
THERMAL AND VIBRATIONAL TESTING	Thermal and Vibrational Testing • -100 to 350F • 5 to 2000 Hz (sine) and 20 t0 2000 Hz (random) force rating of 6300 lbs	Shock and Vibrational Testing **[MSL]** • Unholtz-Dickie T-1000 vibration exciter with 10,000 lb force capability, 1 inch stroke, 5 to 2000 Hz (includes shaker and slip table) Thermal and Vibrational Testing **[USBI]** Thermotron Thermal Chamber **[USBI]** Shaker Table and Controller **[USBI]**	Thermal and Vibrational Testing	Thermal and Shock Testing
HYPERGOLIC TESTING		Hypergolic Testing **[AFL]**	Hypergolic Testing	Hypergolic Testing
HIGH PRESSURE/HIGH FLOW TESTING	High Pressure/High Flow Test Facility • high pressure to 15,000 psig (static) • portable pneumataic amplifier to 10,000 (static) • high flow @ 6,000 psig (GN_2/GHe) at flows of 2 lbs/sec plus	High Pressure/High Flow Test Facility • high pressure to 15,000 psig (static) **[WT]** • high flow to 300 scfm @ 3,000 psig (GN_2/GHe) **[WT]** • 6,000 psig (GN_2/GHe) **[MSL]**	High Pressure/High Flow Test Facility	High Pressure/High Flow Test Facility • 10,000 psig

CAPABILITIES/EQUIPMENT MATRIX

Revision: Baseline

MECHANICAL/FLUIDS TESTING

CAPABILITY DESCRIPTION	FLORIDA LOCATIONS		SPACE SYSTEMS DIVISION	WSTF
	NSLD	KSC/CCAS		
HYDROSTATIC TESTING	Hydrostatic Testing • titanium tube autofrettage to 20,000 psig	Hydrostatic Testing **[USBI]** • 0 to 10,000 psig w/ air driven pump • 100 psi increment gage • DI water test fluid • 84"L x 56"W x 33"H test chamber Hydrostatic Testing • to 21,000 psig **[WT]** • to 10,000 psig GN2 for low volume static component testing **[MSL]**	Hydrostatic Testing	Hydrostatic Testing

CAPABILITIES/EQUIPMENT MATRIX

Revision: Baseline

NON-DESTRUCTIVE EVALUATION & TEST (NDE/NDT)

CAPABILITY DESCRIPTION	FLORIDA LOCATIONS		SPACE SYSTEMS DIVISION	WSTF
	NSLD	KSC/CCAS		
SURFACE DISCONTINUITY EVALUATION (ALL METALS)	Penetrant Inspection • visible and fluorescent methods	Penetrant Inspection **[USBI] [EG&G]** • visible and fluorescent methods	Penetrant Inspection • visible and fluorescent methods	Penetrant Inspection • visible and fluorescent methods
SURFACE AND SLIGHT SUBSURFACE DISCONTINUITY EVALUATION (FERROMAGNETIC METALS ONLY)	Magnetic Particle Inspection (MPI)	Magnetic Particle Inspection (MPI) **[USBI] [EG&G]**	Magnetic Particle Inspection (MPI)	Magnetic Particle Inspection (MPI)
SURFACE AND SUBSURFACE EVALUATION (ELECTRICALLY CONDUCTIVE METALS ONLY)	Eddy Current	Eddy Current **[USBI] [EG&G]**	Eddy Current	
SUBSURFACE EVALUATION	X-Ray Radiography Real Time System **(see Other Capabilities)** Ultrasonic Inspection	X-Ray Radiography IRT Real Time System **[MSL] [EG&G]** Computer Tomography (CT-Scan) **[EG&G]** Gamma Radiography **[EG&G]** Ultrasonic Inspection **[EG&G]** • A-Scan **[USBI]** • P-Scan **[USBI]** • T-Scan **[USBI]**	X-Ray Radiography Neutron Radiography Ultrasonic Inspection	X-Ray Radiography • flash x-ray radiography Ultrasonic Inspection • A-Scan B, Scan-Sonix
PRECISION MEASUREMENTS	Optical Comparator Coordinate Measuring Machine Video Coordinate Measurement Machine (incorporates capabilities of Optical Depth Micrometer and Coordinate Measuring Machine)	Optical Comparator **[MSL] [USBI]** B&S 3-Axis Coordinate Measuring Machine **[MSL]** Johnson Thread Gaging System **[MSL] [USBI]** Cubic Precision Coordinate Measuring System (3 Theodolite/Computer Integrated System) **[USBI]**	Optical Comparator	Optical Comparator
VISUAL INSPECTION OF INACCESSIBLE AREAS	Fiber Optic Borescopes • rigid, flexible, various sizes	Fiber Optic Borescopes **[MSL] [EG&G]** • rigid, flexible, various sizes		Fiber Optic Borescopes • rigid, flexible, various sizes
QUANTITATIVE AND QUALITATIVE LEAK DETECTION	Mass Spectrometer Leak Detection (MSLD)	Varian 938-1 MSLD **[USBI]** • portable • detects leaks to 10^{-6} Std cc/sec Helium MSLD **[EG&G]** • portable • detects leaks to 10^{-12} atm cc/sec Ultrasonic Leak Detection **[EG&G]** • portable Bubble Test **[EG&G]**		
OTHER NDT TECHNIQUES		IR 5500 Thermography System **[MSL]** Spark Testing **[EG&G]** Qualitative/Quantitative Thermal Imagers **[EG&G]** Blackbody Calibrators **[EG&G]**		IR Thermography • Hughes Probeye camera Acoustic Emission Analyzer • 4 channel Phys. Acoustic Corp. Electronic Speckle Patterns Interferometry • 14.5 MeV generator

CAPABILITIES/EQUIPMENT MATRIX

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METALLURGY/FRACTOGRAPHY

CAPABILITY DESCRIPTION	FLORIDA LOCATIONS		SPACE SYSTEMS DIVISION	WSTF
	NSLD	KSC/CCAS		
ELECTRON MICROSCOPY (FRACTOGRAPHY)	JEOL 5800 LV SEM with Energy Dispersive Spectrometry (EDS) • low vacuum capability • 8" diameter chamber Sputter Coater Plasma Etcher	JEOL 6100 SEM with EDS **[MSL]** • 8" diameter chamber Cambridge S-2000 SEM with EDS **[MSL]** • 1' chamber JSM 6400 Analytical Electron Microscope (AEM) with EDS and WDS **[MSL]** Leica Steroscan 420 with EDS and Extended Range Backscatter Detector **[AFL]**	JEOL JSM-840 SEM Amray 1600 SEM/T-N 2000 Light Element EDS ETEC Autoscan/Link EDS ETEC Electron Microprobe	Phillips SEM 515 with EDAX PV0800 EDS
ENVIRONMENTAL TESTING	Salt Fog	Atlas SF-2000 Salt Fog Chamber **[MSL]** Weatherometer **[MSL]** Beach Corrosion Test Site **[MSL]** Beach Corrosion Laboratory **[MSL]** Seawater Immersion System **[MSL]** Corrosion Potential **[MSL]** Stress Corrosion Cracking **[MSL]** Hypergolic Immersion **[MSL]** • ambient temperature Electrochemical Impedance Spectroscopy **[MSL]** DC Electrochemistry **[MSL]** Coatings Applications Laboratory **[MSL]** Glove Box with Controlled Atmosphere **[MSL]**	Salt Fog Corrosion Potential Stress Corrosion Cracking	Salt Fog Hypergolic Immersion AC Electromechanical Impedance Measurement DC Dynamic Polarization Scherography
HARDNESS TESTING	Barcol Microhardness Tester Rockwell • actual Shore Durometers Nondestructive	Barcol **[MSL]** Knoop and Vickers Microhardness Tester **[MSL]** Wilson Model 5TY Rockwell **[MSL]** • actual and superficial Shore Durometers **[MSL]** Brinell **[MSL]** Equotip Nondestructive **[MSL]** Field/Portable Hardness Tester **[MSL]**	Barcol Knoop and Vickrs Microhardness Tester Rockwell • actual and superficial Shore Durometers Equotip Nondestructive	 Microhardness Tester Rockwell • standard and superficial Durometers
METALLOGRAPHY	Metallographic Specimen Preparation • manual and automated Metallurgical Microscope • up to 2000x with photo capability	Metallographic Specimen Preparation **[MSL]** • manual and automated LECO Metallurgical Microscope **[MSL]** • 6.3x to 2000x with photo capability Unitron Metallurgical Microscope **[MSL]** • up to 2000x with photo capability LECO 3001 Computerized/Digital Image Analysis System **[MSL]** Buehler Field/Portable Metallographs **[MSL]** • 50x to 400x	Metallographic Specimen Preparation • manual and automated LECO Metallurgical Microscope • 10x to 2000x Nikon Metallurgical Microscope • 50x to 1000x	Metallographic Specimen Preparation
HEAT TREATING	Heat Treating	Heat Treating **[MSL]**	Heat Treating • vacuum	

CAPABILITIES/EQUIPMENT MATRIX

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CHEMICAL ANALYSIS

CAPABILITY DESCRIPTION	FLORIDA LOCATIONS		SPACE SYSTEMS DIVISION	WSTF
	NSLD	KSC/CCAS		
QUANTITATIVE TRACE DETERMINATION OF METALLIC ELEMENTS (AAS) **QUALITATIVE AND QUANTITATIVE MULTI-ELEMENT ANALYSIS (ICP)**		Jarrell-Ash Inductively Coupled Plasma (ICAP) Simultaneous/Sequential Emission Spectrometer **[MSL]** LECO Model HF-400 Carbon Sulfur Determinator (used with ICP) **[MSL]** Jarrell-Ash AAS **[AFL]** • cold vapor AA • graphite furnace Leeman Inductively Coupled Plasma Emission Spectrometer (ICP) **[AFL]** Perkin Elmer ICP Sequential Emission Spectrometer **[AFL]** Jarrell-Ash ICP **[WT]** Perkin Elmer AA **[WT]** • graphite furnace	Jarrell-Ash Video 22 AAS • Model 188 graphite furnace	Atomic Absorption Spectrophotometer (AAS) • cold vapor AA Inductively Coupled Plasma Emission Spectrometer (ICP)
QUANTITATIVE DETERMINATION OF INORGANIC AND ORGANIC CONTAMINATION	UV and Visible Spectrophotometer	UV and Visible Spectrophotometer **[MSL]** Perkin Elmer Lambda 9 UV and Visible Spectrophotometer **[AFL]**	Hewlett Packard 8451A UV and Visible Spectrophotometer	
DETERMINATION OF TRACE AND SUBTRACE IMPURITIES OF LIQUIDS	Antek Gas Chromatograph with Dual Flame Ionization Detector (GC/FID)	Finnigan-Mat 5100 GC/Mass Spectrometer **[MSL]** Perkin-Elmer Sigma 1B GC **[MSL]** Carle AGC Series 400 GC **[MSL]** GC/FID **[AFL]** GC/TCD/FID **[AFL]** GC/ECD **[AFL]** GC/FTIR/FID **[AFL]** GC/MSD **[AFL]** GC/ELCD/PID **[AFL]** Spectra-Physics High Performance Liquid Chromatograph (HPLC) **[MSL]** Hewlett Packard 1050 HPLC with Diode Array Detector (DAD) **[AFL]**	Perkin Elmer Sigma 2000 Perkin Elmer Sigma 2B Shimadzu GC-8A Varian Vista 5500 Liquid Chromatograph (LC)	GC/FID (Flame Ionization Detector) GC/TCD/FID (Thermal Conductivity Detector/Flame Ionization Detector) GC/ECD/ELCD GC/FSD GC/MSD GC/FID/FFD GC/Ultrasonic Detector GC/MSD with Purge & Trap and Concentrator GC/FID/NPD with Auto Injector GC/NPD with Auto Injector GC/ELCD with Purge & Trap and Concentrator GC/MS (GC with Mass Spectrometer)
RESIDUAL GAS ANALYSIS		Residual Gas Analyzer (Quadrapole MS) **[WT]** Nicolet 20 SXC FT-IR **[AFL]** • 20 M gas cells GC/FID/TCD **[AFL]** GC/DID **[AFL]**		Residual Gas Analyzer
IDENTIFICATION OF IONS IN AN AQUEOUS SOLUTION		Dionex 2120i Ion Chromatograph **[MSL]** Dionex 40001 Ion Chromatograph **[AFL]**	Dionex 40001 Ion Chromatograph	Dionex 20001 Ion Chromatograph Dionex 40001 Ion Chromatograph

CAPABILITIES/EQUIPMENT MATRIX

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CHEMICAL ANALYSIS

CAPABILITY DESCRIPTION	FLORIDA LOCATIONS		SPACE SYSTEMS DIVISION	WSTF
	NSLD	KSC/CCAS		
ORGANIC TESTING	Mattson Galaxy 5020 Fourier Transform Infrared Spectrophotometer (FT-IR) with Microscope	Digilab FTS-40 Spectrophotometer with Microscope **[MSL]** Mattson Galaxy 200 Spectrophotometer with Microscope **[MSL]** Nicolet 20SCX FT-IR **[AFL]** Nicolet 7000 Spectrophotometer **[MSL]** Nicolet MX-5 Spectrophotometer **[MSL]** Digilab FTS-15/90 GC/FT-IR with IR Microscope **[AFL]**	Nicolet 20DXV with Microscope (Spectratech IR-Plan) Beckman IR 4260 • 40M multi-path gas cell	FT-IR Mattson Sirius FT-IR Nicolet 5SXC FT-IR Beckman 4240 IR
IDENTIFICATION OF CHEMICAL STRUCTURES, ANALYIS OF MIXTURES, AND QUANTITATIVE ELEMENTAL ANALYSIS	Mass Spectrometers	CEC model 21-104 Mass Spectrometers **[MSL]** Hewlett Packard Mass Spectrometers **[AFL]**	Perkin Elmer Q-Mass 910 GC/Mass Spectrometer Finnigan-Mat 4500 GC/Mass Spectrometer Perkin Elmer Multiple Gas Analyzer MGA-1200	
THERMAL ANALYSIS OF NON-METALS		Perkin-Elmer DSC7 DSC **[MSL]** Dupont 2910 (DSC/DTA) **[MSL]** Dupont 951 TGA **[MSL]** Dupont 943 TMA **[MSL]**	Dupont 910 DSC Differential Mechanical Analysis (DMA) Differential Thermal Analysis (DTA) Dupont 916 Thermal Evolution Analysis (TEA) Dupont 951 TGA Dupont 943 TMA Evolved Gas Detection System	Differential Scanning Calorimeter (DSC) Differential Thermal Analysis (DTA) Thermogravimetric Analysis (TGA) with FT-IR Thermomechanical Analysis (TMA)
IDENTIFICATION OF CRYSTALLINE MATERIALS BY X-RAY DIFFRACTION		X-Ray Diffractometers (XRD) **[MSL]** Phillips X-Ray Genrator with Automated Diffractometer **[MSL]** Debye-Sherrer XRD Camera **[MSL]** Gandolfi XRD Camera **[MSL]** Phillips PW1800 XRD **[AFL]**	Siemens D500 Automated Diffractometer, Debye-Scherrer Camera	X-Ray Diffractometers (XRD)
BENCH CHEMISTRY	pH/ISE (pH/Ion Specific Electrode Analysis) Viscometers Index of Refraction Non-Volatile Residue (NVR) Specific Gravity Titration	pH Meters **[MSL] [AFL]** Viscometers **[MSL] [AFL]** Flash Point Testing **[MSL] [AFL]** Index of Refraction **[MSL]** Non-Volatile Residue (NVR) **[MSL] [AFL]** Specific Gravity **[MSL]** Titration **[MSL] [AFL]** Coulometric Titration **[AFL]** Density Meter **[AFL]** Total Solids **[AFL]** Automated Distillation Apparatus (ADA) **[AFL]** Particle Counts **[AFL]**	pH Meters Viscometers Flash Point Testing Non-Volatile Residue (NVR) Specific Gravity Titration	pH Meters Viscometers Flash Point Testing Index of Refraction Non-Volatile Residue (NVR) Specific Gravity Coulometric Titration
DETERMINATION OF ELEMENTAL CONCENTRATION USING X-RAY FLUORESCENCE	Energy Dispersive X-Ray Fluorescence Spectrometer (XRF)	Energy Dispersive X-Ray Fluorescence Spectrometer (XRF) **[MSL]** Phillips PW1400 XRF **[AFL]**		

CAPABILITIES/EQUIPMENT MATRIX

Revision: Baseline

CHEMICAL ANALYSIS

CAPABILITY DESCRIPTION	FLORIDA LOCATIONS		SPACE SYSTEMS DIVISION	WSTF
	NSLD	KSC/CCAS		
QUANTITATIVE DETERMINATION OF MAJOR AND TRACE ELEMENTS, QUALITATIVE ELEMENTAL ANALYSIS		Jarrell-Ash Inductively Coupled Plasma (ICAP) Spectrograph **[MSL]**	Jarrell-Ash Autocomp 1100 ARL 1.5 Meter Film Reading Spectrograph	Optical Emission Spectrograph
SEPARATION AND QUANTITATIVE ANALYSIS OF VARIOUS MATERIALS		Capillary Electrophoresis System **[MSL]** GC/MS **[AFL]** GC/FT-IR **[AFL]**		
ANALYSIS TECHNIQUE USED TO INVESTIGATE DISCOLORATION AND CONTAMINATION OF SURFACES		Kratos XSAM 800 X-Ray Photoelectron Spectrometer (XPS/ESCA) **[MSL]**		Perkin Elmer PHI5600 (ESCA)
IDENTIFICATION OF CONTAMINANTS OF LIQUIDS		Finnigan 700 I Ion Trap Detector **[MSL]** GC/MS **[AFL]** GC/FT-IR **[AFL]**		
MONITORING AND ANALYZING ENVIRONMENTAL CONDITIONS		Total Organic Carbon (TOC) with Auto Sampler **[WT]** CO_2 Analyzer **[WT]** Mercury Analyzer **[WT]** THC Analyzer **[WT]** Oxygen Analyzers **[AFL] [WT]** Hydrocarbon Analyzers **[AFL]** Moisture Analyzers **[AFL]** Mercury Vapor Analyzer **[WT]** Moisture Monitors **[WT]** Hydrazine Monitors **[WT]** NO_2 Monitor **[WT]** Drager Instruments (endless monitoring capabilities) **[WT]**		Total Organic Carbon (TOC) with Auto Sampler CO_2 Analyzer Mercury Analyzer THC Analyzer Oxygen Analyzer Trace Water Analyzer NOX Analyzer Portable Organic Vapor Analyzer Surface Area Analyzer Mercury Vapor Analyzer Environmental Sensors Conducting Organic Polymer Environmental Sensor Hydrazine Monitors NO_2 Monitor HCL Monitor CO Monitor
QUALITATIVE AND QUANTITATIVE ANALYSIS OF METALS AND NON-METALS IN SOLUTION				Polargraph/Mercury Drop Electrode
HYDROGEN DETERMINATION IN METALS	**see Other Capabilities**			

CAPABILITIES/EQUIPMENT MATRIX

Revision: Baseline

NON-METALLICS PROCESSING

CAPABILITY DESCRIPTION	FLORIDA LOCATIONS		SPACE SYSTEMS DIVISION	WSTF
	NSLD	KSC/CCAS		
EQUIPMENT IN SUPPORT OF NON-METALLICS PROCESSING	Autoclave • 600F maximum • 29.5 inches Hg vacuum to 100 psi maximum	Autoclave **[MSL]**	Autoclave • 600F maximum	
	Clean Room • Class 100,000	Clean Room • Class 400 **[WT]** • Class 10,000 **[MSL]** • Class 100,000 **[USBI]**	Clean Room	Clean Rooms • Class 100 • Class 10,000
			Composite Layup	
	Diamond and Carbon Steel Saw Blades (cut HRSI tile)	Diamond Saw Blades **[MSL]**	Diamond Saw with Vacuum Dust Collection (cut HRSI tile)	Diamond Saws
	Foam Spray Booth	Foam Spray Booth **[MSL]**	Foam Spray Booth and Machines	
	Fume Hoods	Fume Hoods	Fume Hoods	Fume Hoods • fuels and oxidizers
		Hydraulic Press **[MSL]**	Hydraulic Presses • up to 100 tons	Hydraulic Press
	Kiln (@ TPSF) • 2500F		Kiln and Muffle Furnace • 3000F	Kilns
	Ovens	Ovens	Ovens • Blue M to 1600F	
	Precision Cleaning	Precision Cleaning **[WT]**	Precision Cleaning	Precision Cleaning
	Primer Spray Booth		Primer Spray Booth	Primer Spray Booth
	Vacuum System • 28 inches Hg	Vacuum System • 28 inches Hg Vacuum Chamber **[USBI]** • 24" ID x 48"L • 2 TORR to 24 inches Hg	Vacuum System • 28 inches Hg	
	Vacuum Conditioning • to 10^{-4} TORR and 400F	Vacuum Conditioning **[MSL]** • to 10^{-6} TORR • 70 to 200C Izod & Charpy Impact Testers **[MSL]**	Vacuum Conditioning • to 10^{-6} TORR	

CAPABILITIES/EQUIPMENT MATRIX

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PHYSICAL TESTING

CAPABILITY DESCRIPTION	FLORIDA LOCATIONS		SPACE SYSTEMS DIVISION	WSTF
	NSLD	KSC/CCAS		
TENSILE AND COMPRESSIVE TESTING	Chatillon • to 500 lbs Instron • to 44K lbs	Elevated/Low Temperature Testing **[MSL]** Tinious Olsen **[MSL]** • to 120K lbs Instron **[MSL]** • to 20K lbs SATEC, Servo-Hydraulic Compressive and Tensile **[MSL]** • to 600K lbs Impact Testers **[MSL]**	Elevated/Low Temperature Testing MTS Machines • 1 lb to 500K lbs Impact Tester Low-Cycle Fatigue Tester	 Tensile Testers Compression Testers Experimental Stress Analysis Impact Testers Low-Cycle Fatigue Testers Slow Strain Rate Tester
CALORIMETRY			Anter Labs Drop Calorimeter • 200 to 1800F (needs repair) Lion Research Emissometer • room temperature Rockwell Emittance Calorimeter • -200 to 100F Comparative Thermal Conductivity System • -300 to 1000F Dynatech Comparative Thermal Conductivity Test System • -300 to 1800F Colora Thermoconductometer • 100 to 300F Rockwell Axial Heat Flow Conductivity Test System • -300 to 100F Dynatech Guarded Hot Plate Test System • -300 to 1800F • air or vacuum Rockwell Cryostat • -440 to -320F Rockwell Dilatometer • -300 to 1800F	Accelerating Rate Calorimeter Parr Bomb Calorimeter Thermal Hazards Screening Calorimeter Microcalorimeter Cone Calorimeter • O_2 enrichment to 50%
LUBRICATION TESTING		4-Ball Wear Tester **[MSL]** 4-Ball Extreme Pressure Wear Tester **[MSL]** Friction and Wear Tester (block on ring) **[MSL]** Cone Penetration **[MSL]** Dropping Point **[MSL]** Oxidation Stability **[MSL]** Evaporation Loss **[MSL]** Effect of Copper on Oxidation Rate **[MSL]** Constant Temperature Bath **[MSL]** • to 400F		

CAPABILITIES/EQUIPMENT MATRIX

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OPTICAL PROPERTIES

CAPABILITY DESCRIPTION	FLORIDA LOCATIONS		SPACE SYSTEMS DIVISION	WSTF
	NSLD	KSC/CCAS		
TESTING OPTICAL PROPERTIES OF MATERIALS		Absorptance Reflectometer (out of service) **[MSL]** Emittance Reflectometer (out of service) **[MSL]**	Emissometers Fiber-Optic Spectroreflectometer Low-Temperature Emittance Calorimeter Optical Breadboard Vibration UV-Vis-Near IR Spectroradiometer UV-Vis-Near IR Spectroreflectometer Portable IR Reflectometer	Blackbody Sources N2 Laser Pumped Visible Dye Laser • .25 NM resolution Germanium Diode Detector Array • 256 elements Silicone Diode Detector Aray • 1024 elements UV-Visible Spectrometer Near IR Spectrometer Mid-IR Fourier Transform

CAPABILITIES/EQUIPMENT MATRIX

Revision: Baseline

SPACE ENVIRONMENT EFFECTS

CAPABILITY DESCRIPTION	FLORIDA LOCATIONS		SPACE SYSTEMS DIVISION	WSTF
	NSLD	KSC/CCAS		
EFFECTS OF SPACE ENVIRONMENT ON MATERIALS		Compatibility Testing **[MSL]** Triboelectric Test System with Temperature/Humidity Chamber **[MSL]** Flammability Testing **[MSL]** Thermal Vacuum Stability Testing **[MSL]**	Arc Lamp Systems • near UV Combined Environment Plasma Reactor • AO and UV radiation Combined Environment Chamber with UV-Vis-Near IR Spectroreflectometer Electrostatic Discharge Measurement System Experimental Plasma Reactor Low Temperature Asher Lyman Alpha Source • far UV and calibration system Thermal Vacuum Stability Testing UV-Vis Spectroradiometer Corona Testing	Compatibility Testing Flammabililty Testing Limiting Oxygen Index Tester Odor Assessment Thermal Vacuum Stability Testing

CAPABILITIES/EQUIPMENT MATRIX

Revision: Baseline

OTHER CAPABILITIES

CAPABILITY DESCRIPTION	FACILITY/LOCATION
REAL TIME RADIOGRAPHY	Fein Focus USA, Inc. 5142 North Clareton Drive, Suite 160 Agoura Hills, CA 91301 Phone: 818/889-1440 Fax: 818/889-3787
HYDROGEN DETERMINATION IN METALS	Metals Technology 19801 Nordhoff Northridge, CA 91324 Phone: 213/873-7144